

THE CRINOID FAUNA OF THE KNOBSTONE FORMATION.

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In connection with my researches on the fossil Crinoidea I have encountered continual difficulty relative to the stratigraphic position of a number of important species from the Lower Carboniferous described from southern Indiana, Kentucky, and Tennessee, and found in collections made by Troost, Safford, Lyon, Wachsmuth, Pate, Greene, and others. These species in the descriptions and upon the labels in collections have been referred to a horizon where it has seemed to me increasingly more evident they do not belong.

Lyon, writing in 1860 on the "Stratigraphical arrangement of the rocks of Kentucky,"¹ gave a general section of the strata of western Kentucky, which he divided into beds designated from *A* to *X*, in descending order, grouped in two large divisions. The upper of these he called the "Millstone Grit series," including all above the Cavernous (St. Louis) limestone, and the lower the "Sub-Carboniferous series," in which he included the Black slate and the Devonian beds of the Falls of the Ohio. Taking this division above the black slate in ascending order, his beds were: *P*. Sandstones and shales; *O*. Middle limestone; *N*. Cavernous limestone. The last is clearly the St. Louis limestone of the Missouri and Iowa geologists. His "Middle limestones," *O*, he found to contain in the lower part fossiliferous beds equivalent to the Spergen Hill beds of Indiana (Spergen). His "Sandstones and marls," *P*, he says are "frequently distinguished as the Knobstone beds," and he describes them as varying in thickness from two to three hundred feet, the upper part consisting of "alternate beds of muddy sandstone, aluminous shale, and plates of limestone of variable thickness * * * sometimes largely charged with beds of chert, the lower part of beds of aluminous and marly shale, with occasionally thin beds of fine sandstone." He considers the upper part equivalent to the crinoid beds near Scottville, Allen County; the marly lower beds he says are best known in Bullit and Jefferson counties as "Button-mold Knob."

¹ Trans. Acad. Sci. St. Louis, vol. 1, pp. 612-621.

Safford, in 1869,¹ divided the Lower Carboniferous of Tennessee into two groups, designated in ascending order as "(Sa) Siliceous Group," and "(Sb) Mountain limestone." His Mountain limestone included everything between the St. Louis and the Coal Measures, *i. e.*, the Kaskaskia. The Siliceous group he subdivided into two members, the "Upper or Lithostrotion bed," equivalent to the St. Louis limestone of the Missouri geologists, and the "Lower or Protean member," including everything from the St. Louis down to the Black slate. He considered this member as "more especially the equivalent of the Keokuk limestone" (p. 342), but adds that "it contains, however, some Burlington forms." His descriptions and sections show it to be of a variable character, but in a general way to be composed of argillaceous beds, or shales, in the lower part, and more or less siliceous, or cherty, limestones in the upper, with irregular occurrence of limestone bands among the shales and cherts.

The Lower or Protean member of Safford's Lower Carboniferous corresponds to Lyon's bed *P*; and the name "Knobstone," as mentioned by Lyon, has been given to it currently because of its exposure in many of the isolated hills, or "knobs," which form a conspicuous feature of the topography of southern Indiana and northern Kentucky. But it extends over a wide area in Kentucky and Tennessee where the knobs do not occur. In the latter state it has received the name of "Tullahoma formation," and is applied to such well-known localities as Whites Creek Springs, Tenn., and Allen and Metcalfe counties, Ky., at all of which species of undoubted Keokuk type occur. In Indiana the name "Knobstone" is adhered to, as given by Owen in 1859.² In the earlier reports of the State Geological Survey a clear distinction was recognized between the Knobstone shales, with intercalated calcareous layers, the succeeding Burlington, and the Keokuk limestone beds. In the report for 1878 (p. 379) some good sections are given of exposures in Harrison County, which is a westward continuation of the Kentucky knob region, showing over 200 feet of Knobstone shales and sandstones, including at the upper part 8 to 15 feet of thin bands of "red encrinital limestone," and above that, after several different beds of various colored siliceous clays, slates, flints, and cherts of from 30 to 70 feet, heavy Keokuk crinoidal limestone to a thickness of 40 feet or more. An earlier report, 1874 (p. 115-118), recognized the Knobstone as distinct from the Burlington and Keokuk, and treated the part consisting of sandstones and underlying bluish and greenish (New Providence) shales as equivalent to the Chemung, Waverly, and Kinderhook. It says that the "Button-mould wash," so called from the disk-shaped segments of crinoid stems found in it, is but another

¹ Geology of Tennessee, p. 339.

² Report of a Geological Reconnaissance of Indiana Rocks in 1839, p. 21.

name for the greenish marly shale of these beds; and it mentions as among the fossils occurring in these "washes" imperfect specimens of *Cyathocrinus*, *Platycrinus*, *Synbathocrinus*, *Actinocrinus*, and *Forbesiocrinus* (p. 122).

In the Fifteenth Report, 1885-86, on the Geology of Washington County, by Gorby (p. 124), it is very clearly shown that the Burlington beds are represented by certain irregular buff to gray limestones occurring between the shales and sandstones of the Knobstone and other limestones and cherts in which Keokuk species prevail; and he says (p. 132): "The tendency of the evidence leads strongly to the conclusion that these beds of this (Burlington) group separate the Keokuk from the Knobstone throughout the greater portion of Washington and Harrison Counties." In some localities in these counties red or buff limestone layers have yielded undoubted Upper Burlington species; and in Washington County certain buff, geodiferous beds lying very close to the Knobstone shales contain a characteristic Keokuk crinoid fauna, with many species identical with those found at Indian Creek, in Montgomery County.

It may be here remarked that little dependence is to be placed upon color as distinguishing the Burlington and Keokuk beds in the Indiana-Kentucky region; the one may be red and the other blue at one place, and the colors exactly reversed a short distance away; and colors of the same bed often change in short distances. In the Burlington-Keokuk beds of the typical region along the Mississippi River, which was a center of deposition with little disturbance, the coloration is extremely regular and characteristic, and a person whose early collecting was in these localities is apt to attach too much importance to color elsewhere. The southern Indiana region especially was one of many changes, and frequent invasions and recessions of the waters, accompanied by much erosion and replacement during the epoch which the Keokuk-Burlington-Warsaw beds represent; so that their thickness is extremely irregular, and in many places their vertical section is greatly reduced. Thus there may be characteristic Burlington and Keokuk, or Keokuk and Warsaw, fossils at the same exposure from a few feet of strata. There have also been extensive later denudations cutting through several beds of rocks, and redistribution of the material, with its contained fossils, from one area to another, so that those from two or three successive formations may be found together in the same bed of clay. This is clearly stated in the last-mentioned report (p. 135), and is borne out by the experience of every careful collector. For instance, the well-known locality of Spergen Hill, which name is really applied to fossils collected over an area of several square miles covered by a deposit of reddish ferruginous clays, containing the

residuum of decomposed limestones, chiefly the so-called Oolite of the Salem quarries, which form the surface rocks of the region. This clay is very fossiliferous, and specimens from it are found in many collections, in some labeled "Warsaw" and in others "St. Louis." These names mean here the same thing—a bed of foraminiferal limestone and the clay composed of its decomposed remains, characterized by a great abundance of *Pentremites conoideus*, usually called Warsaw by the Indiana geologists and often St. Louis by others. It is immediately underlaid by the Keokuk, which is exposed in some places, as in the railroad cut at Spergen Hill, and from the erosion of which its fossils have also sometimes been mingled in the same red clay and have taken on its color. A few have been obtained directly from the rocks and are of its original bluish-gray color. Therefore, while the great majority of the fossils labeled "Spergen Hill" are doubtless derived from the Spergen beds, it is always possible to find a true Keokuk species among them.

Returning now after this digression to the Knobstone, the later Indiana geologists did not adhere to its distinct separation from the beds above it, as was done by those of 1874–85, but the Geological Survey of that state¹ has extended it so as to definitely include, in the north, the typical Keokuk crinoid beds of Crawfordsville and Indian Creek in Montgomery County.

There being thus included in this formation, in all three of the states mentioned, crinoidal beds yielding species of a true Keokuk fauna correlating strictly with the occurrences at the typical localities in Iowa and Illinois, it came to pass that the entire so-called "Knobstone" of Indiana and Kentucky, and Tullahoma of Tennessee, have been regarded by some geologists as belonging to the Keokuk epoch, and collectors labeled their fossils derived from it indiscriminately as "Keokuk." All the species described by Miller and Gurley from these beds have been referred to the Keokuk; and S. A. Miller went so far as to claim that the Waverly beds at Richfield, Ohio, also belong to the Keokuk; and in the second Appendix to his *North American Geology and Paleontology*, 1897, he referred all the species of crinoids described by Hall from that locality to that horizon. (See also Bull. No. 12, Ill. State Mus., p. 11.)

This prevalent conception of the stratigraphy of these beds has completely ignored the possibility of the prolific Kinderhook and Burlington series being represented in them, somewhere between the Black Slate and the Upper Siliceous limestones of undoubted Keokuk equivalency—and it illustrates how, even in science, people will often go on following the leader without knowing why.

Now, to the systematic student of the crinoids, seeking to find out something of their actual geologic succession and phylogenetic

¹ Twenty-sixth report, for 1901, pp. 263, 272.

relations, it makes considerable difference whether a given species is said to be derived from the Keokuk Limestone or from the lower beds of the Burlington or the Kinderhook, for these stand for the extremes in what is probably the best, and best preserved, line of local crinoid development in all geological history. The Burlington and Keokuk beds represent the acme of crinoidal life, both in variety of form and profusion of individuals, and it was the overwhelmingly predominant faunal feature of those epochs. So profuse is its development that it has been proposed by Wachsmuth and Springer and by Keyes to recognize this by grouping the two formations into a distinct division of the Lower Carboniferous, for which Keyes¹ proposed the name "Augusta," and Williams, before him,² with slightly different limitations, that of "Osage."

Of more importance than this, however, is the fact that faunal considerations have required us to further subdivide it, so as to recognize the upper and lower beds of the Burlington as well marked and distinct horizons. There is a thoroughly well-defined succession in the crinoidal fauna, beginning in the Lower Burlington with a predominance of species characterized by great delicacy of form and beauty of ornamentation, and culminating in the Keokuk with prevalent forms of large size, rough ornamentation, and much exaggeration of structural details, in many cases marking the extinction of the genera. Between these there is a distinctly intermediate condition, represented by the Upper Burlington. The three formations are separated by heavy transition beds of chert, each marking the extinction of most of the species and some of the genera of the bed preceding it, and the inauguration of a rougher habit in the forms which follow. These facts were pointed out long ago by White,³ Wachsmuth and Springer,⁴ and Keyes.⁵ The modifications here indicated do not apply to all the species, some simpler forms of a more generalized type persisting through the beds with little change, while in some there was a distinct retrogression, resulting in ultimate extinction through diminished vitality. But in the specialized and predominant types, like *Camerata*, the process of acceleration and abrupt termination from one bed to another and at the close of the epoch was most striking.

The focus of this profuse development of crinoidal life was the region near and west of the Mississippi River, in Iowa, Illinois, and Missouri. It was a deep and clear water formation, little disturbed by oscillation or other causes, and continuous through a long period, except for the changes produced by the repeated increase in the

¹ Iowa Geological Survey, vol. 1, 1892, p. 61.

² Bull. 80, U. S. Geol. Surv., 1891, p. 109.

³ Journ. Boston Soc. Nat. Hist., vol. 7, 1860, pp. 224-225.

⁴ Proc. Acad. Nat. Sci. Philadelphia, 1878, p. 229.

⁵ Geol. Surv. Iowa, vol. 1, 1893, p. 65.

siliceous content of the water at the end of the subordinate periods. The main beds of each period are formed of remarkably homogeneous limestones, very regularly and evenly stratified, almost entirely composed of the calcareous remains of countless myriads of crinoids, and interrupted only by the siliceous invasions above mentioned, resulting in the deposition of the heavy cherty beds of passage between the different members. It has a total thickness of upward of 200 feet of solid limestones and chert, the latter being one-third or more of the whole. The chert beds are not wholly barren, for thin bands or lenses of limestone are found irregularly throughout them, often filled with remains of crinoids that struggled through under the changed environment. The coloration of the limestone beds is remarkably uniform for each horizon. There is little muddy shale until rather late in the Keokuk, when there were evidently considerable changes of level, with migration into shallower waters to the eastward, resulting in the deposit of the shale beds of the Crawfordsville region in Indiana.

These facts indicate an unusually favorable condition for a succession of life during long periods, and for this reason the Mississippi River region above indicated is taken as the typical one for this formation, with which other occurrences of any of its members should be compared, when considering their faunal or stratigraphic relations. This was not the case with the occurrences in southern Indiana and Kentucky, where, as already pointed out, there must have been frequent changes of level and of chemical constituents, resulting in much irregularity and interruption in the deposition of the strata and variability in their fossil contents. There was evidently a strong migration of Keokuk species to the southward, for there is a more definite assemblage of typical forms in Kentucky and Tennessee than in the central Indiana region.

The boundary between the two Burlington beds is really more sharply marked than that between the Burlington and Keokuk, there being a much more gradual transition of forms between the latter, and the passage beds being more fossiliferous. Between the Lower Burlington and the beds preceding it there is no such definite line of separation.

In White's original section at Burlington¹ the top of the Kinderhook—his bed No. 7—is shown to be an impure limestone, sometimes magnesian, which passes insensibly into the Lower Burlington Limestone. It is thin at that point, but thickens to the northwest to 40 feet of limestone containing the rich fossil beds of LeGrand, in Marshall County; and to the southward it also thickens to upward of 100 feet in Missouri, where it takes the name in part of the Louisiana and in part the Choteau Limestone; and occasional highly fossiliferous beds of shale, like those at Fern Glen, may constitute a

¹ Geology of Iowa, vol. 1, 1870, p. 193.

part of it. While there is some difference in species between this and the beds called Lower Burlington, yet the general type remains the same, and there is no such extinction of genera and of conspicuous species as is found between the later members of the formation. Below this bed are a number of irregular layers, mostly of limestone, some of them oolitic, brecciated, or shaly, and some of sandstone; all of them extremely variable locally and in many places absent; but everywhere at the base of the formation is a great thickness of argillaceous and sandy shales overlying the Black Slate. If the crinoidal content of the formations is to govern, it would probably be more logical and would simplify the geology of the formation if all these beds above the heavy shales and lower sandstones were ranked with the Lower Burlington as one member. Those parts of the formation embraced in the Upper Burlington and Keokuk, representing a period of culmination and extinction, are of relatively restricted extent, while the earlier portion, namely, Lower Burlington-Choteau-Waverly-Kinderhook (in part), is of very wide geographical distribution. It is found on the flank of the Rocky Mountains, in New Mexico and Montana, and the Mountain Limestone of Great Britain and Belgium is substantially its equivalent, containing most of its characteristic genera, and many species scarcely distinguishable, but none of those peculiar to the succeeding members here.

No one acquainted with the fauna of this formation, as disclosed at numerous localities in the typical region above indicated, would ever mistake a set of crinoids from the Lower Burlington for Keokuk, or the opposite. While a few of the more generalized forms, like *Cyathocrinus*, are similar, the characteristic species are widely different, and several important genera have become wholly extinct within the Burlington, *e. g.*, *Megistocrinus*, *Amphorocrinus*, *Cactocrinus*, *Steganocrinus*, *Telciocrinus*, *Strotocrinus*, the discoid *Platy-crini*, *Metichthyocrinus*, *Mespilocrinus*, *Wachsmuthicrinus*, *Belemnocrinus*, and the blastoid genera *Orophocrinus*, *Schizoblastus*, *Cryptoblastus*, *Orbitremites*, and *Codaster*. On the other hand, the paired arm structure so frequent in the Keokuk—as in *Dizygocrinus*—is known in but one species in the Lower Burlington; the large and rugose *Actinocrini*, *Dorycrini*, and *Agaricocrini* are represented only by a few small and delicate species; and the important genera of the Flexiblia, *Onychocrinus* and the so-called *Forbesiocrinus* of the type of *F. wortheni*, etc., not at all. In the typical region there is no trouble whatever in distinguishing these beds by their crinoidal fauna.

But when we come to species described from the southern Indiana-Kentucky-Tennessee region, and the collections made therein by Lyon, Safford, Wachsmuth, Greene, and others, I have been constantly

perplexed by the reference to the Keokuk horizon of many forms, including several genera which had never been seen in that position in the typical region, but which would have seemed perfectly at home in the Lower Burlington. These reputed occurrences seriously interfered with the logical sequence of several specialized genera, whose position was otherwise perfectly clear. After a while I came to suspect that the real trouble lay in the correlation of the Knobstone beds, and I concluded to undertake a reexamination of that region, with a view of determining the actual horizon of its fossils. In this I was encouraged by Doctor Weller of the University of Chicago, who expressed the opinion, based upon his own extensive studies of the Kinderhook, that the Knobstone fauna was more likely to prove Kinderhook than Keokuk.

Accordingly, in 1909, I sent the veteran collector, Frederick Braun, into the field to make a careful and systematic collection from the so-called Knobstone beds from the northern limit of the knobs in Indiana, to and including the famous Button-mould Knob region of Jefferson and Bullit counties, Kentucky, and thence as far south, along the Devono-Carboniferous outcrop, as time would permit. He spent the entire season at this work, covering the ground thoroughly from Washington and Clark counties, Indiana, to Marion County, in central Kentucky. Good specimens of crinoids have always been rare at the Knobs, but Braun was instructed to collect minutely all fragments and detached plates. In this way he accumulated a large quantity of material from the weathered slopes of the talus—the so-called Button-mould washes—and from ravines and fields formed by their erosion. The crinoids are chiefly derived from the disintegration of thin limestone bands interbedded in the argillaceous shales and marls, and are usually highly silicified, often pure flint. It is rarely possible to find them in place, and therefore we can not designate the exact layers from which they came; but it is usually practicable to fix their approximate limits, and to say whether they were derived from the main body of the Knob, or only from siliceous limestones at the upper part of the section.

This material, when assembled, showed clearly—

1. That there were no characteristically Keokuk forms in the débris of the Knobs in southern Indiana, or those of the Button-mould Knob region; but farther south in Marion County, where well-defined heavy beds of siliceous limestone cap the hills, true Keokuk species, such as *Dorycrinus gouldi*, *Actinocrinus jugosus*, *Agaricocrinus americanus*, began to appear, more or less intermingled with the others, but their origin was evident.

2. That the whole fauna, except the last-mentioned occurrences, is of unmistakably Lower Burlington type.

3. That this fauna includes a number of reputed Keokuk species occurring at Whites Creek Springs, Tennessee, where true Keokuk forms are also known to occur; among these the rare "*Ichthyocrinus*" *tiaræformis* of Troost.

As the Whites Creek region was known to present a section from the Niagara to the Warsaw, and to be one of tremendous erosion, it now seemed probable that the equivalent of the Button-mould Knob beds would be found there, although not heretofore recognized, with an intermingling of fossils from the erosion of these and the overlying Keokuk beds, which would account for the confusion of faunas already mentioned. I therefore thought it advisable to have that region carefully searched anew, under the guidance of an experienced geologist. I was so fortunate as to enlist the interest of Dr. R. S. Bassler, of the U. S. National Museum, in the question, and he readily consented to undertake the examination, which he made in company with Mr. Braun, in June, 1910, after first carefully studying the beds at Button-mould Knob and vicinity. My thanks are due to Dr. Richard Rathbun, assistant secretary of the Smithsonian Institution, for kindly granting Doctor Bassler leave of absence from office duties for that purpose.

Doctor Bassler's observations, more fully set forth in his accompanying paper, clearly demonstrated that the Button-mould Knob beds are present at Whites Creek, and fully confirmed the suspicion of the intermingling of their fossils with those of the Keokuk limestones above. His researches have cleared up the complex stratigraphy of that region, and placed the correlation of the Knobstone beds upon a sound basis, as shown in his account, where the geological details are given in full. A series of authentic collections, made at the same time by Mr. Braun, makes possible a close comparison of the Whites Creek fauna with that of the Knobs. In addition to this, I have had the advantage of examining the collection of the Vanderbilt University in Nashville, which was generously placed at my disposal by Prof. L. C. Glenn, of the department of geology of that institution. It includes the original collection of Safford, with others since made by Professor Glenn, and is a useful addition to the other material when interpreted in the light of our present knowledge of the Whites Creek beds.

I may mention also that during Mr. Braun's work of 1909 he made a general collection of other fossils at the Knobs, which I placed in the hands of Doctor Weller, who informs me that he finds them of a decidedly pre-Keokuk type. And in this connection I would also call attention to Weller's paper on the fauna of the Fern Glen formation,¹ from shaly layers immediately underlying limestones referable

¹ Bull. Geol. Soc. America, vol. 20, pp. 265-332.

to the Burlington. These beds are undoubtedly equivalent to some part of the Knobs series, and some of the species occurring there will be referred to in the list which is to follow.

The locality of Whites Creek is an extremely interesting one. It was referred to by Safford in his *Geology of Tennessee*, 1860, page 342, as a good representative of his Lower, or Protean, member of the Lower Carboniferous. He gave a list of the fossils occurring there, of which he said: "Most of the above species occurring outside of Tennessee are Keokuk forms." And from that day to this every fossil collected at Whites Creek above the Niagara beds has been labeled "Keokuk," if the local name, Tullahoma, was not employed. As before stated, the section in the vicinity extends from the Niagara to the Warsaw. According to Bassler's section, a bed of green Kinderhook shale overlies the Black Slate, followed by about 35 feet of rather light gray limestone, which is massive on first exposure, but upon weathering produces material similar to that in the talus of the middle or upper layers in the Knobs. This limestone is highly fossiliferous, and contains numerous crinoid remains. Above it is a heavy bed of siliceous Keokuk Limestone, containing crinoids similar to those of Barren County, Kentucky, and of the typical Keokuk. This weathers to a reddish, or dirty yellow, clay, which imparts its color to objects embedded in it.

The country is rough, with many hills, ridges, or small mountains, separated by numerous ravines and gullies leading to level fields below. Erosion has been great, and the gullies and fields contain the washings from the entire slopes of the ridges and mountains, often deposited in thick and very ancient clay beds. The reddish Keokuk Limestone caps the hills, while the gray limestone overlying the shales is in the slopes below it.

Now, fossils found in place at the top of the hills can be depended upon as Keokuk; they are usually reddish or dirty yellow in color, like the rock containing them, highly siliceous, and often geodized—a frequent occurrence in the Keokuk. Those found in place in the gray limestone are a dirty bluish or gray, sometimes geodized, but more often entirely replaced by silica as solid as flint. But these same fossils, when transported by erosion down the slopes, and buried under soil washed from the beds above, take on a reddish or reddish-brown color; and as the fossils of both beds are highly siliceous, it is impossible to distinguish such specimens with certainty by their physical appearance. Again, the fossils from the upper beds, when long embedded in the clays derived from the gray limestone, or from the shales below it, have lost their reddish color and have come to resemble those of the lower limestone. It is evident, therefore, that specimens found in the washes, gullies, slopes, or fields below the top of the hills may be from either the Keokuk or the gray limestone;

and if below the upper level of the latter, may be from both intermingled. This was the condition in a plowed field where Wachsmuth, over 20 years ago, made one of the best collections ever obtained at Whites Creek, in which the fossils, although evidently mostly from the gray limestone, as we now know, were nearly all of the reddish or yellowish color of the soil. In fact, we not infrequently find a specimen which is partly reddish and partly bluish, from having been buried in partial contact with a clay derived from one or the other of the beds.

Furthermore, in such limestones as these gray beds we may expect small bands or pockets colored with ferric oxide, from which the fossils come out reddish or yellowish. This is quite frequent in the limestones and cherts at Burlington. I would also expect to find the bluish color from the lower beds running up to the Keokuk layers.

Hence we can not depend upon color as a guide to the origin of the specimens, and it should be disregarded altogether in their consideration.

Alloprosallocrinus conicus, for instance, is an unquestioned Keokuk species, and we find it both red and blue; so with *Lobocrinus nashvillae*, and *Agaricocrinus americanus*. On the other hand, species known to occur in the Knobstone layers of Button-mould Knob are found here in both colors—as, for instance, *Metichthyocrinus tiaraeformis*, *Catillocrinus tennesseensis*, etc. In general, it may be said that the fossils from the lower limestone are usually more solid flint, and less often geodized, while those of the Keokuk beds are more imperfectly silicified, and frequently geodized. Neither is this a reliable criterion, as these differences are sometimes found elsewhere in one and the same bed.

The crinoids of this locality are more frequently found intact than at the Knobs, and we were fortunate in securing a fair series of them from each bed in place; these furnish a firm basis of comparison to begin with. They include the following species:

A. Undoubted Keokuk, from top of hills:

Agaricocrinus americanus.

Agaricocrinus nodulosus.

Lobocrinus nashvillae.

Alloprosallocrinus conicus.

Eretmocrinus ramulosus.

Eretmocrinus prae-gravis.

Dorycrinus gouldi.

B. Below the Keokuk, in grey limestone:

Eretmocrinus, large arm fragments and parts of calyx—probably

E. yandelli.

Agaricocrinus, small species with 10 arms.

Metichthyocrinus tiaraeformis.

Barycrinus cornutus.

Barycrinus, cf. *rhombiferus*.

Cyathocrinus, small smooth species.

Cyathocrinus, elongate and highly ornamented.

Poteriocrinus, large elongate species.

Catillocrinus tennesseensis.

Halysiocrinus perplexus.

Synbathocrinus robustus.

Every one of list B was found at Button-mould Knob, but not one of list A.

The material obtained by Braun from the Knobs, while abundant in quantity, seemed rather discouraging at first, owing to its fragmentary character. Along with a few complete calices, it consisted mainly of an immense number of loose calyx plates. Many of these, however, were of forms marked by conspicuous and delicate ornamentation, such as occur peculiarly in the lower beds at Burlington; and by patiently assorting them, I found that I could separate a large number of specific forms, in some cases finding enough of the different plates of a form to enable me to reconstruct representative specimens, sufficient for figuring hereafter, in the case of several new species. These, added to what I already had from previous collections, notably the Lyon collection acquired by me some years ago, gave me a total of some 45 species from the Knobs, which can be compared with those of other localities.

With these explanations, necessary for a proper understanding of the relations of this fauna, I will give a list of the species found in the Knobstone beds of various localities, and some known to be from Keokuk beds, lying above those under consideration. To save some needless repetition, I will first give the localities to be referred to:

George Palmer's farm, Clark County, Indiana.

Stone's farm, 9 miles southeast of Borden County, Indiana.

Near Henryville, Clark County, Indiana.

Williams' farm, near Rush Creek, Indiana.

Button-mould Knob, Bullitt County, Kentucky.

Bradbury Knob, Bullitt County, Kentucky.

Jacobs Knob, Bullitt County, Kentucky.

Bells Knob, Marion County, Kentucky.

Bradfordsville, Marion County, Kentucky.

Sallietown, Marion County, Kentucky.

Whites Creek, Davidson County, Tennessee.

Fern Glen, 20 miles west of St. Louis, Missouri.

LIST OF THE KNOBSTONE CRINOIDEA.

GILBERTSOCRINUS Phillips.

G. cf. tenuiradiatus Hall, Lower Burlington, Burlington, Iowa.

This is only a fragment, consisting of part of an interradial appendage, rather delicate, ornamented with small, sharp tubercles on the dorsal side, and, what is most important, having only two rows of covering plates—a true Burlington type, never found in the Keokuk, where all species have four.

Locality.—Button-mould Knob.

ERETMOCRINUS Lyon and Casseday.

1. *E. yandelli* (Shumard). (Trans. Acad. Sci. St. Louis, vol. 1, 1860, p. 76.) Syn. *E. prodigialis* Miller and Gurley. (Bull. No. 7, Illinois State Mus., 1895, p. 39.)

Referred to Keokuk Group by all authors. I have the types in the Lyon collection from Button-mould Knob, and good specimens were found there and in neighboring knobs by Braun. Arm fragments of some large *Eretmocrinus* were found in the same bed. This well-known species was referred by Waeshsmuth and Springer to *Lobocrinus*,¹ to which I do not now agree; in the absence of the arms which have not been found attached, it is difficult to place satisfactorily, but is more probably an *Eretmocrinus*. It has not the projecting basal rim of the genus generally, but this is true also of some Lower Burlington forms, where the genus is represented by several species; and it ranges from the Kinderhook to the Keokuk. This species has not been found except at the Kentucky Knobs. Miller and Gurley described *E. prodigialis* upon a specimen of it from the type locality, unusually mature, and having abnormally a few extra arms. This species has superficially more of a Keokuk aspect than any of the others of the supposed Knobstone fossils. It is very large for the genus, and has a rugose appearance from its highly tumid plates both dorsally and ventrally; but these plates on the ventral side, in well-preserved specimens, are found to be covered with a distinct ornamentation formed by small raised tubercles, such as is not usual in Keokuk forms. A number of specimens have been found, all in the so-called "washes" at Button-mould and adjacent knobs; but none at any true Keokuk locality.

Locality.—Button-mould and Jacobs Knobs, Kentucky; not found at Whites Creek.

2. *E. praegravis* Miller.

3. *E. ramulosus* Hall.

¹ North American Crinoidea Camerata, 1897, p. 441.

These are both large species, from the typical Keokuk or passage beds from the Burlington; they are found in place in the Keokuk beds at the top of the hills at Whites Creek, but are not found at the Knobs.

4. *E. cf. matuta*. A small species occurring in the Lower Burlington; several good specimens at Whites Creek.

LOBOCRINUS Wachsmuth and Springer.

L. nashvillae Hall, is another typical Keokuk and Upper Burlington species, found in the Mississippi River region, and in Barren and Metcalfe counties, Kentucky. It occurs in the Keokuk beds at Whites Creek, where it was found in place, but not at the Knobs in Bullitt County. It is reported from one locality in Marion County, where it probably came from the limestone beds at the top.

L. robustus Wachsmuth and Springer. Described from Whites Creek; found in the upper Keokuk beds, and not found at the Knobs.

DORYCRINUS Roemer.

D. gouldi Hall. Typical Keokuk species of Iowa; is found at Whites Creek, but not at Button-mould Knob.

AGARICOCRINUS Hall.

A. americanus Roemer.

A. nodulosus Meek and Worthen; both typical Keokuk species; are abundant in the Keokuk beds at the top of the hills at Whites Creek but not found at the Knobs. There are fragments of large *Agaricocrinus* at Button-mould, unidentifiable, and a small form, with ten arms, that might be a Burlington or Keokuk species.

MEGISTOCRINUS Owen and Shumard.

Fragments of large stems, clearly belonging to this genus, are found at Button-mould and Bradbury Knobs, but have not been noted at Whites Creek. It is a Devonian genus, becoming extinct with the Burlington.

AMPHORACRINUS Austin.

Spinous tegmen plates belonging to this genus occur at Button-mould and Bradbury Knobs, Whites Creek, and at Fern Glen, Missouri. This is essentially a Choteau-Lower Burlington genus, ending with the latter horizon, where it is represented by two fine species. Species have been described from the Kinderhook of Jersey County, Illinois, the Choteau of Sedalia, Missouri, and the Waverly of Richfield, Ohio; and it occurs at Lake Valley, New Mexico. It is also one of the leading crinoids of the Mountain Limestone of England. It is emphatically a pre-Keokuk genus, and did not so far as known even enter the Upper Burlington.

ACTINOCRINUS Miller.

A. jugosus Hall, or a similar species, occur at Whites Creek, but not found in place. The base and loose plates of the same type were found at the Joe Bell Knob, near Lebanon, Kentucky, associated with *Dorycrinus gouldi*, and probably came from the upper limestone. There are also a few loose plates at Button-mould Knob referable to some species of *Actinocrinus*. The genus ranges from the Lower Burlington to the Keokuk.

CACTOCRINUS Wachsmuth and Springer.

Arm fragments characteristic of this genus, with short, spiny nodes on every third, fourth, and fifth brachial, were found at the Knobs. No trace of this genus has been seen above the Lower Burlington.

Localities.—Button-mould Knob; Stone's Farm; Whites Creek; Fern Glen.

PLATYCRINUS Miller.

Many detached radial plates, and a few basal disks. All are of Lower Burlington types, and not one of them can be positively referred to a Keokuk species or type. Several forms can be distinguished which may be compared with described species as identical or closely allied. My comparison is mainly with species known at Burlington, and not with those described by Miller from the Chateau of Missouri, some of which are probably closer, but of which I have not the specimens at hand.

1. Discoid form, base only; small, thick, with very coarse nodes, elongated toward the corners of the basal pentagon: cf. *P. yandelli* Owen and Shumard, Lower Burlington.

Locality.—Button-mould Knob; Bradbury Knob, Kentucky.

2. Low discoid form, base only; very small with a single prominent node just below each corner of basal pentagon: May be *P. americanus* Hall, or young of *P. yandelli*, both Lower Burlington.

Locality.—Button-mould Knob.

3. Discoid form with very long radials, and facets projecting beyond the limits of the calyx, proximal part of the rays very deep and narrow. It is the form described by S. A. Miller from the Lower Burlington at Sedalia, Missouri, as *P. occidentalis*,¹ which is a good species of this type, and not a synonym, as stated in North American Crinoidea Camerata, page 728.

Locality.—Whites Creek, in place in the gray limestone; it occurs also at Fern Glen, and a form probably identical with it is abundant in the equivalent beds at Lake Valley, New Mexico.

The discoid *Platycrini* are characteristically Lower Burlington, and not Keokuk.

¹ Bull. No. 4, Geol. Surv. Missouri, p 10.

4. Elongate form, with straight sides; very thin plates, perfectly smooth, with small radial facets, deeply indented: *P. planus* Owen and Shumard; Lower Burlington; also found in the Mountain Limestone of Belgium.

Locality.—Button-mould Knob; also Lake Valley, New Mexico.

5. Similar to the last, but with a few small nodes, forming lines from radial facets to middle and corners of plates.

Locality.—Button-mould and Bradbury Knobs, Kentucky.

6. Elongate form, with slightly spreading sides; thin plates, very small facets, but little indented in upper margin of radials; plates evenly curved, but little depressed at the sutures. Very fine nodes or tubercles, sometimes confluent, forming faint lines parallel to margins of plates. One good calyx and detached plates. Is nearer to *P. granosus* de Koninck and Lehon of the Mountain Limestone of Belgium than to any American species, but may be compared with *P. scobina* Meek and Worthen, Lower Burlington.

Locality.—Button-mould Knob.

7. Erect form, not elongate, slightly spreading; small facets, directed upward; fairly thick plates with beveled sutures; rows of moderate sized nodes run from facets to corners of radials: *P. pocilliformis*, Lower Burlington Limestone.

Locality.—Whites Creek; one good calyx.

8. Erect form, large, spreading calyx; thin plates; facets wide and shallow; ornamented with good-sized nodes, thickly distributed without definite arrangement on basals and radials.

Locality.—Button-mould Knob; similar form from Fern Glen, Missouri, and Lake Valley, New Mexico.

9. Elongate form, medium size, with spreading cup and stronger plates than the preceding; ornamented with a few scattered nodes on radials and basals; radial facets wide and shallow: *P. verrucosus* Hall, Lower Burlington, but larger than usual at Burlington.

Locality.—Button-mould Knob.

10. Elongate, calyx moderately spreading; large, with strong plates; radial facets wide; smooth, or slightly marked with obscure ridges: *P. sculptus* Hall, Lower Burlington.

Locality.—Button-mould Knob; Bradbury Knob; and Bell Knob, near Lebanon, Kentucky. This is the only form that might perhaps be referred to a Keokuk species of *Platycrinus* or *Eucladocrinus*. Some plates from Bell Knob are more elongate than those at Button-mould Knob, but similar variations from moderate to quite elongate can be seen among specimens from Burlington labeled as above.

11. Base of a small, smooth species, similar to *P. burlingtonensis* Owen and Shumard, Lower Burlington.

Locality.—Stone's farm, Clark County, Indiana.

A close comparison with actual specimens from the English Lower Carboniferous may show some of the above forms to be indistinguishable from them by the calyx alone. It is interesting to note in passing that the only American *Platycrini* having a long anal tube like *P. laevis* of the English and Irish Mountain Limestone, as figured by Austin, are one from the Lower Burlington and one from the Lower Carboniferous beds in Nevada. The best known and best preserved species of the Burlington and Keokuk have nothing of the kind.

WACHSMUTHICRINUS Springer.

1. *W. spinosulus* (Miller and Gurley). Described as *Ichthyocrinus*, and said by the authors¹ to have been "found in Clark County, Indiana, in what is called the Knobstone, but which we think must be of the age of the Keokuk Group."

Locality.—Several specimens are from Stone's farm, Clark County, Indiana, and Mr. Greene informs me that the type was found by him at the same place.

2. A smooth form, without nodes or spines, undescribed, from the same locality, and also from the Knobstone beds in the neighborhood of Junction City, Kentucky, along the outcrop eastward from Lebanon.

This genus is characteristically Lower Burlington, a single specimen only being known from the upper bed. It occurs also at Fern Glen, Missouri, Lake Valley, New Mexico, and in the Mountain Limestone of England.

MESPILOCRINUS de Koninck and Lehon.

Good specimens of two new species at Button-mould Knob and at Stone's farm; also stem fragments at Fern Glen, Missouri. The genus occurs in the Mountain Limestone of Belgium and England, and in the Lower and (rarely) Upper Burlington Limestone at Burlington, and in the Choteau of Missouri. It is a highly specialized form, and no trace of it has ever been seen in the Keokuk rocks.

METICHTHYOCRINUS Springer.

1. *M. tiaraeformis* (Troost, Hall). Described as *Ichthyocrinus*, and the horizon is stated by Hall, Wachsmuth and Springer, and Miller, simply as the Subcarboniferous. Oral tradition has always assigned it to the Keokuk, and in the republication of Troost's Monograph² the horizon is given as the "Keokuk horizon of the Tullahoma formation." The type is from Whites Creek, of a rather neutral, or dirty yellowish color. I have another almost identical with it; one of a more reddish color; and two of a decided

¹ Bull. Illinois State Mus., No. 5, p. 45.

² Bull. 64, U. S. Nat. Mus., p. 100.

bluish gray, one of which came directly out of the gray limestone of that locality. There is also a very dark, flinty specimen from a knob just south of Louisville.

2. *M. clarkensis* (Miller and Gurley); said by the authors to be from the Keokuk or Warsaw Group, Clark County, Indiana.¹ I have specimens of it from the Knobstone at Stone's farm, and near Henryville, Clark County, Indiana, and I have no doubt that the type came from the same horizon; I also have it from Button-mould Knob.

The genus is well represented in the Lower Burlington by *M. burlingtonensis*, and the species, or a similar one, occurs at Fern Glen, Missouri. Fragmentary specimens from Button-mould Knob might also be referred to it, as it can not be distinguished from *M. clarkensis* by the base alone. Only one doubtful specimen of the genus has been reported from the Upper Burlington, and no indication of it has ever been seen in the typical Keokuk.

TAXOCRINUS Phillips.

A highly ornamented form, of which we have only broken parts of calyx and arms, not resembling any Keokuk species, but nearer to an undescribed species from the Lower Burlington at Burlington.

Locality.—Button-mould Knob; Stone's farm, Clark County, Indiana.

FORBESIOCRINUS de Koninck and Lehon.

Calyx plates similar to those from the Mountain Limestone of Tournai, Belgium, were found at Stone's farm, and Palmer's farm, Clark County, Indiana, and Button-mould Knob, Kentucky; also at Fern Glen, Missouri, and Lake Valley, New Mexico. Recent studies of the type, and some better specimens since found, of de Koninck and Lehon's species, *F. nobilis*,² have shown that this is a good genus, and that the name will stand as proposed by the authors. But the Belgian species belongs to a type quite distinct from all the American species which have been described under this name, with the single exception of Hall's *Forbesiocrinus communis*³ from the Waverly Group at Richfield, Ohio, a horizon equivalent in part to the Knobstone.

F. saffordi (Hall),⁴ the largest species of the genus. The original specimen came from Whites Creek, and is of a preservation much resembling those specimens found in place in the Keokuk beds. I have several specimens of the species from the red clays of the Warsaw horizon at Spergen Hill, Indiana, and there is no doubt that it belongs to the upper, true Keokuk, beds at Whites Creek.

¹ Bull. No. 5, Illinois State Mus., p. 43.

² Rech. Crin. Carb. Belg., 1854, p. 121.

³ Pal. Ohio, vol. 2, p. 169; pl. 12, figs. 4, 5; not fig. 3.

⁴ Suppl. Geol. Iowa, 1860, p. 87.

EURYOCRINUS Phillips.

This genus was described from the Lower Carboniferous of Yorkshire, England. It has since been recognized in the Devonian of this country, and a well-defined species is now found in the Knobstone beds of Whites Creek and the Knobs of Kentucky and Indiana.

SYNBATHOCRINUS Phillips.

1. *S. robustus* Shumard.¹ Originally described from Button-mould Knob, where the author says it is "rather abundant in the blue marl layers, interstratified with the fine grained sandstone." It is listed as from the Keokuk Group by Worthen,² Wachsmuth and Springer,³ Miller,⁴ and Weller.⁵ It is an abundant and widely distributed species, notable for being, when mature, the largest of the genus. I have it from Palmer's farm, Clark County, Indiana; Button-mould and Bradbury Knobs, and Bradfordsville, Kentucky; and Whites Creek, Tennessee. At Whites Creek we find it in both the reddish and bluish preservation, and in place in the grey Knobstone beds, but not in the Keokuk beds above. Worthen's specimen, figured in Geological Survey of Illinois, vol. 6, plate 29, was from Greene County, Illinois, where Kinderhook, Burlington, and Keokuk are all present, although the Kinderhook is said to be nonfossiliferous. It is possible, however, that it came from the Keokuk beds, and is an unusually large example of *S. swallowi*, which occurs in the Keokuk and Warsaw. *Synbathocrinus* is one of the genera which persists through the crinoidal formation with but little change, and species from the different horizons are often hard to distinguish. It is to be noted, however, that the specimens of this genus occurring at undoubted Keokuk localities in southern Indiana and Kentucky are invariably much smaller than *S. robustus*, and this species has not been found at any locality where the Knobstone beds do not occur. The genus begins in the Devonian, occurs abundantly in the Lower and Upper Burlington of Iowa and Missouri, culminating in the latter, and becoming extinct in the Warsaw. It is found in the Lake Valley beds of New Mexico, and the Mountain Limestone of England; a species is described by Wetherby from the Kinderhook beds at Kings Mountain Tunnel, Kentucky, and one by Hall from the Goniatite Limestone (Kinderhook) of Rockford, Indiana.

Locality.—As above stated.

2. *S. angularis* Miller and Gurley,⁶ is described from Button-mould Knob, as Keokuk. A small form with more angular plates than the last, but found associated with it, and perhaps only its younger stage.

¹ Trans. Acad. Sci. St. Louis, vol. 2, 1866, p. 397.

² Geol. Surv. Illinois, vol. 6, p. 514.

³ Rev. Pal., vol. 3, p. 169.

⁴ North Amer. Geol. and Pal., 1889, p. 285.

⁵ Bull. 153, U. S. Geol. Surv., p. 618.

⁶ Bull. No. 5, Illinois State Mus., p. 42.

Locality.—Button-mould and Bradbury Knobs, Kentucky; and Stone's farm, Indiana.

HALYSIOCRINUS Ulrich.

1. *H. perplexus* (*Cheirocrinus perplexus* Shumard),¹ is described from Button-mould Knob as "in blue calcareous shale, supposed to be of the age of the Keokuk division of the Archimedes Limestone," and listed as of that horizon by Wachsmuth and Springer, Miller, and Weller. A very large, broad-based form, with surface strongly granular or pustulose.

Locality.—Very abundant at the type-locality, and more rare at Bradbury Knob and in Marion County, Kentucky; Whites Creek, Tennessee; Palmer's farm, Clark County, Indiana.

2. A medium-sized, much narrower form occurs at Stone's farm, Clark County, Indiana, perhaps undescribed.

This genus also comes up from the Devonian and is well represented in the Burlington and Keokuk, where it ends. The Knobstone species, especially the large pustulose form, is much nearer to one occurring in the Hamilton of Alpena, Michigan, than it is to the Keokuk forms of Iowa and Indiana.

CATILLOCRINUS Shumard.

C. tennesseae (Troost) Shumard.¹ Troost's type was from Whites Creek, Tennessee, as stated by Shumard, who saw the specimen at Nashville in 1847. The specimens in the Troost collection, mentioned in the publication of his monograph, Bulletin 64, U. S. National Museum, page 25, are said to be from Button-mould Knob. Those from which Shumard made his description were from the latter locality "in blue marls and marly limestones, which I suppose to be of the age of the Keokuk division," and the species is listed from that horizon by Wachsmuth and Springer, Miller, and Weller. I have numerous specimens from both the above localities, and also from Palmer's farm, Clark County, Indiana. It has never been found, to my knowledge, in any typical Keokuk locality in Iowa, Illinois, Missouri, or Kentucky. Gorby² reports it as occurring in the red Warsaw clays on Rush Creek in Williams's farm, 8 miles northwest of Salem, Indiana, associated with numerous "*Pentremites* of various species, and *Batocrinus*, *Alloprosallocrinus*, and several specimens of *Catillocrinus tennesseae* Troost, which are locally known as 'quart cups.' " If actually found so associated, it must have been in some gully where the Warsaw fossils were mixed with Knobstone, which is exposed to a thickness of 50 feet on the same farm. I have good specimens of the genus from the

¹ Trans. St. Louis Acad. Sci., vol. 2, 1866, p. 358.

² Fifteenth Rep. Geol. Indiana, p. 137.

typical Keokuk at Crawfordsville and Indian Creek, and they are much smaller than this, as are also those of the Upper Burlington.

This is the largest species of the genus, and it has been thought that this makes for the Keokuk character of the horizon. But the fact is that the course of this genus was one of degradation and gradual extinction of vitality. It represents a high specialization, which began in the Devonian with *Mycoerinus* of the Eifel and persisted through this genus into the St. Louis, where its last representative, as found at Huntsville, Alabama, is a depauperate form of very diminutive size. Therefore it is perfectly in accord with the facts to consider that the line of development culminated in size with the present species in the marls of the Knobstone, not later than the age of the Lower Burlington.

CYATHOCRINUS Miller.

This is a genus of wide geographical distribution and long life. It is a form of simple organization and generalized type, its calyx consisting of infrabasals, basals, radials, and an anal plate, just as we find in the larva of some *Antedons* to-day. It ranges from the Silurian to the end of the Keokuk. It underwent slight changes with time, and ran its course to extinction without any extravagant development, as is usually the case with the simpler types. Except by the color, and character of the matrix, it is hard to distinguish between a smooth *Cyathocrinus* of the Burlington and one from the Keokuk. About 10 species are recognized from the Silurian, chiefly from Gotland; true *Cyathocrinus* has not been noted in the Devonian, but its acme came in the Lower Carboniferous, from which there have been described species referable to the genus as follows: Mountain Limestone of England, 9; Kinderhook, 1; Choteau, 1; Lower Burlington, 7; Upper Burlington, 6; Keokuk, 18; from which numbers some deduction must be made for synonyms, especially in the Keokuk. The species described and listed from the St. Louis, Maxville Group (=Kaskaskia), and Lower and Upper Coal Measures do not belong to this genus.

Cyathocrinus was evidently a very prominent erinoid in the Knobstone formation, and flourished in profusion in a variety of beautiful forms, most of them highly ornamented; several of them are undescribed. The Lower Burlington described species are mostly small, and a majority of them smooth. The ornamented ones, or some of them, are represented or closely paralleled by species at some of the Knobstone localities. My material from the Knobs consists chiefly of isolated plates; but by separating these into well-defined groups and reconstructing some calices in part, it is sufficient to indicate the existence of at least 8 well-marked species, and to afford a good description of them by which they can be readily identified. Most of these

are represented at Whites Creek, where we find better preserved calices of some of the species.

1. Rather elongate, large, and robust. IBB low; BB large, elongate; RR smaller than BB; radial facets deep, directed outward. Ornamented with low ridges and broad furrows from facets to center of BB and down to IBB, also from center to center of BB, where they meet in a prominent knob. This is of the type of *C. barrisi* of the Lower Burlington, but much stronger and coarser. Much closer to it, however, is *C. kelloggi* White, which is a large species with similar ridges and broad furrows, and tumid basals, and the two forms may well be identical. Doctor White's species is stated in the description¹ to be from the Keokuk Limestone. This must have been a pure *lapsus pennæ*. I have the type-specimen before me, with the original label by Doctor Barris (to whose collection it belonged) showing that it came from Honey Creek, Henderson County, Illinois. The Keokuk is not exposed at that locality, but the Burlington is, quite extensively, chiefly the upper bed, although the section in the vicinity goes down to the Kinderhook. From the appearance of the specimen itself no collector familiar with these rocks would ever mistake it for Keokuk. I have other specimens of it from the Upper Burlington, and that may be safely taken as its horizon. Two English Mountain Limestone species have similar knobs at the center of the basals, but the ridges, if present, are not well shown in the types. A similar ornamentation is found in a Keokuk species which is abundant at Indian Creek, Indiana, and Boonville, Missouri, but the specimens are uniformly small, with a low calyx and concave base.

Locality.—Button-mould, Bradbury, and Bell Knobs, Kentucky; Palmer's farm, Clark County, Indiana; and Whites Creek, Tennessee, from which I have a complete calyx. Plates are so abundant at some of the other localities that I have reconstructed a large calyx from them.

2. Elongate, large, with tall, erect IBB; BB elongate, longer than RR, and not protuberant; RR rather short, radial facets rather shallow, directed outward. Surface highly ornamented with numerous strong, rugose wrinkles or tubercles, tending to become confluent, usually in no definite order. There is considerable variety in size and shape of the tubercles, but all follow the same general plan. It is a very striking and beautiful species. *C. rigidus* White, from the Lower Burlington, has a somewhat similar pustulose surface, but the pustules are well separated, and the calyx is small, low, and rotund. *C. conicus* Phillips, from the Mountain Limestone of England, has a rather similar elongate form, but the type does not show distinct ornamentation. The species may be compared with *C. multibrachiatum* of the Keokuk, which is similarly large and elongate, but usually

¹ Proc. Bost. Soc. Nat. Hist., vol. 9, p. 8.

has only a few scattered tubercles, though some specimens have them considerably like this.

Locality.—Button-mould, and other Knobs in the vicinity, and in Marion County, Kentucky; Palmer's and Stone's farms, Clark County, Indiana; Whites Creek, Tennessee. From the latter I have a very large calyx, supplementing a good reconstructed calyx from the other localities.

3. Elongate, medium size, with high BB apparently much larger than RR, which have deep, narrow facets, not projecting and directed outward; IBB not found, but probably high, as in the last species. Surface very strongly ornamented with sharp, elevated ridges and narrow furrows radiating from the facets and passing three or more parallel to centers of BB, thence to centers of adjoining BB, and down to the IBB. It is superficially similar to species 2, but distinct in form of radial facets and regular arrangement of ornament into ridges; the isolated plates of the two can be separated with certainty at a glance. There is no other American species with which it can be compared; *C. lamellosus* White, from the Upper Burlington, faintly resembles it in its few sharp ridges, but it is short and of a very different type. But it will need very close comparison with a species described by Austin¹ and erroneously referred to *C. geometricus* Goldfuss; it is said in the text to be from South Devon, but I suspect it is Lower Carboniferous.

Locality.—Button-mould and Bradbury Knobs, Kentucky; and Stone's farm, Clark County, Indiana.

4. Elongate, medium size; a delicate species with thin plates. BB elongate, RR large, probably larger than BB, with deep facets not projecting and directed outward; IBB not found. Surface thickly studded with very small granules tending to become confluent and form fine lines at right angles to the sutures; and a very prominent five or six pointed star in the center of BB, composed of strongly elevated sharp ridges running nearly to the edge of the plates, where they thin to fine points and do not pass to adjoining plates; similar ridges radiate from the radial facets, but not reaching the sutures. There is nothing to compare this with, save the last species, of which it may be a modification; but we can never mistake a plate of one for the other on account of the fine, granular surface outside of the ridges in this, whereas in the last the intervening surface is perfectly smooth. We have a reconstructed calyx minus the IBB.

Locality.—Button-mould and Jacob's Knobs, Kentucky; and Palmers, Clark County, Indiana.

5. Rather broadly rotund, medium size; with low IBB; large BB, as wide as long, much larger than RR and not protuberant; RR short and wide, facets rather large and not projecting, facing obliquely

¹ Monog. Rec. and Foss. Crin., p. 61, pl. 7, figs. 5a-c.

upward. Surface very finely and uniformly granulose, the granules sometimes forming fine striæ toward or parallel with the margins of the plates. Comparable in general form with *C. fragilis* of the Lower Burlington, which lacks the granulose surface. A reconstructed calyx.

Locality.—Button-mould Knob, Kentucky.

6. Rotund, medium size, with thick plates. IBB low; BB rather longer than wide, strongly convex and gibbous; RR smaller than BB, with large projecting facets facing outward. Surface finely granulose. Except for the distinct granulose ornamentation, this form may be compared with *C. nodosus* of the Keokuk; also with *C. bursa* and *C. calcaratus* of the English Mountain limestone. It is probably the same species described by Meek and Worthen as *C. saffordi* and by Troost (MS) as *C. pentasphericus*.¹

Locality.—Button-mould and Bradbury Knobs and Newmarket, Kentucky; from the latter two complete calices.

7. Medium sized; elongate, campanulate, narrow at base and abruptly widening at the arm bases owing to the large size of RR, which constitute nearly one-half of the calyx. IBB small, erect; BB about half the size of RR; facets large, facing outward. All plates smooth, BB and RR low convex, without ornament, or with possibly some low obscure pustules on BB only, not on RR. In its turbinate form and smooth surface this can only be compared with *C. choteauensis* of the Missouri Choteau.

Locality.—Only identified at Whites Creek, where a specimen was found in place in the Knobstone beds; but smooth radials probably of the same species are frequent at the Knobs.

8. Similar in general form and proportion of plates to the last; but more strongly campanulate. All plates gibbous, with a few large, rough pustules in the median parts and bordering the facets. It is very similar in form to *C. barydactylus*, from the highest part of the Upper Burlington.

Locality.—Good calices were found at Whites Creek in washes below the Knobstone, but it was not identified at the other localities.

While some of the foregoing species of *Cyathocrinus* are undoubtedly indecisive of the horizon, yet it can not be denied that the entire facies is suggestive of the Lower Burlington in a more luxuriant development than at the typical locality. It is significant that in all the careful collecting made at the true Keokuk localities in Barren, Metcalfe, and Allen counties, Kentucky, by Lyon, Wachsmuth, and Wetherby, not a single specimen of any of these species appears, and that none of them are among the fossils found in place in the Keokuk beds by Bassler and Braun at Whites Creek.

¹ Bull. 64, U. S. Nat. Mus., p. 84, pl. 5, figs. 6, 7, 8.

I have not undertaken to give names to these forms, preferring to wait until proper illustrations can be prepared and closer comparison made with described species; but I have little doubt that most of them are new.

~ BARYCRINUS Meek and Worthen.

This was also a prominent genus in these beds. It ranges from the Lower Burlington to the Warsaw, but has not been recognized in the European Lower Carboniferous. It is a more specialized type than *Cyathocrinus* in its arm structure, and the course of its development through the crinoidal formation was more in accordance with the general rule. The species in the Lower Burlington are relatively small, with delicate ornamentation, while those in the Keokuk are mostly large and coarse, one of them being the largest Inadunate crinoid in the American rocks. Some types persisted through with little change recognizable in the fossils, and some forms from the typical Burlington and Keokuk can scarcely be distinguished from one another except by the color and matrix. This is especially so in forms with a more or less stellate base. Seven species have been described from the two Burlington beds and the Choteau; 21 from the Keokuk, of which at least half are synonyms; 2 from the Warsaw; and 1 said to be from the St. Louis of Jersey County, Illinois, which is doubtless from the Warsaw also. About six species are represented among the isolated plates from the Knobs, some of them by complete calices at Whites Creek, along with some additional species.

1. Medium to small size, low, with broad base. IBB very small and flat; BB about as large as RR; facets very large, rather deep and elliptic, more resembling those of *Cyathocrinus* than usual in this genus. The dorsal surface is traversed by remarkably elevated, sharp, keel-like ridges, connecting the facets laterally and running from them without a break to the center of the basals, thence less conspicuously branching to the infrabasals; these divide the calyx into ten deep and wide pits, somewhat resembling a colony of Lithostrotion corals. Isolated radials of this form can be at once recognized from all others by the four large, sharp ridges projecting like cogs from the rim of the facet, which occupies almost the entire radial. Three good calices and a number of plates were found at Whites Creek showing these characters beautifully. Now this is the very kind of sculpturing, only more pronounced, that is found in a remarkably beautiful specimen from the Lower Burlington that has been for many years in my collection labeled "*B. rhombiferus* Owen and Shumard." It has the arms perfectly preserved, and the same kind of high, knife-like wrinkles extend for their entire length; but on each axillary the wrinkle is produced into a short spine, as is also the case

with another Lower Burlington species, *B. cornutus*. Such peculiar sculpturing has not been found on any *Barycrinus* later than the Lower Burlington, and as shown in these specimens it is doubtless a strong exaggeration of that of *B. rhombiferus*, as described, and usually labeled in collections; this form is beautifully ornamented with fine wrinkles, from which the above more striking characters were perhaps derived, and it has also decidedly shallower and wider radial facets. As the form now described can be recognized without the least doubt, either by the calyx or a single radial, I have thought best to designate it at once as a new species, *Barycrinus asperrimus*.

Locality.—As above stated at Whites Creek. It was not found at the Knobs, but I have plates belonging to it from the equivalent beds at Lake Valley, New Mexico.

2. A species with long, horn-like, irregular, projecting nodes on radials and basals, readily identifiable as *B. cornutus* Owen and Shumard, of the Lower Burlington Limestone. *Barycrini* with stellate base, *i. e.*, with a broad, projecting ridge from infrabasals to basals, giving a star-like effect, are found throughout the Burlington and Keokuk, and several species have been described upon slight modifications of detail in this. In this species the projections on basals and radials are confined to the plates on which they originate, and are often peculiarly contorted nodes, pulled out to all kinds of irregular ends, like a piece of clay when pulled in two. The surface is otherwise smooth. The axillary brachials, where the ramules are given off from the main arms, are produced into spines, which become long and slender toward the distal end of the arms.

Locality.—Calyx plates with the nodes above described, and spiniferous axillary brachials, some with spines half an inch long, are found at Button-mould and neighboring knobs in Kentucky; at Stone's farm, Indiana; Fern Glen, Missouri; and at Lake Valley, New Mexico. Also a completely typical calyx at Whites Creek, Tennessee; this has a radianal, as occasionally occurs in this genus, and the Burlington specimens of this species have either an unusually large anal plate for the genus, or two, with RA sometimes showing only at the interior.

3. A less rugose and smaller protuberance on BB and RR, more distinctly rounded or spiny, gives a form closely related to the last, described by Hall as *B. stellatus*, from the Iowa Keokuk. It is a rather small species, quite abundant at Indian Creek, Indiana, and it has also spiniferous axillary brachials. Both have very wide, shallow radial facets, directed obliquely upward. The two forms are closely related, and doubtless shade into one another; but while the typical *cornutus* has not been found above the Lower Burlington the present one is represented there as well as in the Keokuk.

Locality.—Several good specimens were found at Whites Creek, and at Newmarket, Kentucky; the latter from the Knobstone shales, the former among intermingled fossils, some reddish and some bluish-gray, from both Keokuk and Knobstone, with the probability that most of them came from the latter.

4. Another closely related, rather small form is that of *B. quinquelobus* Meek and Worthen, described from the Warsaw Group of Illinois and found at several localities of the typical Keokuk. With only moderate and often no projections on the radials, the center of the basals is abruptly elevated to a small point; from this a strong ridge, widening and tending to form a shallow grooved depression between the margins, runs to the infrabasals, giving the distinct form of a large, five-pointed star involving the whole basal portion of the calyx. The name "*stellatus*" would have been absolutely appropriate for this. This form of base is best defined in the Keokuk forms, but may be traced from the Lower Burlington, where it is found in *B. rhombiferus*.

Locality.—Good specimens of this are found in the Knobstone shales at Newmarket, Kentucky, and at Whites Creek in a red preservation of uncertain horizon. I have also very characteristic specimens of it from the top of the Keokuk or Warsaw near Colesburg, Hardin County, Kentucky.

5. Another small form, with very small, tumid BB, and extremely large, convex RR, with large, deep facets facing laterally, is somewhat like *B. tumidus* Hall, from the Iowa Keokuk. From the deep radial facets, and the appearance of some arm fragments that may belong to it, it is possible that this and the next form may belong to *Cyathocrinus*. Their low calyx and flat base, unusual in that genus, and the extreme size of the facets, occupying almost the entire plate, lead me to place it here; but it has an erectness, and absence of spreading in the calyx, which are unlike *Barycrinus*. Only the definite association of arms can settle it.

Locality.—There are good specimens from Button-mould Knob—one complete calyx—and several from Whites Creek, in both reddish and bluish preservation, but none found in place.

6. In the last four species the surface is smooth and without ornament. There is another form, in shape and size closely resembling the last, and possibly a *Cyathocrinus*, in which the plates, in addition to being tumid, are surrounded by a number of more or less prominent, small nodes, sometimes tending to arrange themselves in rows from center to center; they fringe the margins of the radial plates like rows of beads, and also the brachials (of which three are in place in a ray of one specimen) all the way around to the ventral furrow.

Aside from the ornament it has some general resemblance to *B. bullatus* of the Keokuk.

Locality.—Separate brachials with the bead-like fringe of nodes are found at the Knobs, and complete calices at Whites Creek.

7. A large, low, wide-spreading species, with finely wrinkled, granulose surface ornament in a variety of forms; the surface of the plates bent into broad, low ridges branching from RR, meeting on BB, and passing down to IBB, with a slight median groove, leaving 10 shallow, lozenge-shaped depressions at the corners where three plates meet. This is the general form and structure of *B. wachsmuthi* of the Lower Burlington, and *B. sculptilis* of the Upper; but it has relatively thinner plates than those species. The surface sculpturing is delicate, and not suggestive of any of the large Keokuk species.

Locality.—Plates of this are common at Button-mould and Bradbury Knobs, Kentucky, and at Stone's and Palmer's farms, Indiana, from which calices have been reconstructed; also at Whites Creek. There is also a large, coarse form, with heavy plates, at the latter locality, probably referable to one of the smooth Keokuk species.

8. Large, low, spreading calyx, with very convex radials and strongly tumid basals, without any connecting ridges, and with perfectly smooth surface; it is a good example of *B. bullatus* Hall, of the Iowa Keokuk.

Locality.—Whites Creek, from slope with mixed fossils, below level of Knobstone.

While, as in *Cyathocrinus*, several of these species are not decisive of horizon, two of them are of distinctly Lower Burlington type, and there are few among the others which might not belong to that formation; so the weight of evidence, upon this genus alone, is in favor of that horizon rather than Keokuk.

POTERIOCRINUS Miller.

The true *Poteriocrinus*, which includes only a few out of the vast number of species described under this name, is represented by at least two species. The genus, beginning in the Devonian, is a strong fossil of the Mountain Limestone of England and Belgium, and in this country ranges from the Lower Burlington to the Keokuk.

1. Large, elongate, with very thin plates which are flexed into deep folds, leaving broad, elevated bands composed of several more or less sharp ridges, passing from the radial facets to one another and to the basals, converging at the middle and passing down to the infrabasals; a pair of such striated bands passes right and left from one basal to another, with fine granulose ornament between. These markings are very conspicuous, and the plates become as thin as paper at the sutures. BB elongate, much larger than RR, which are

short, with small, deep, and narrow crescentic facets, having a transverse ridge. IBB of this species not found, but calyx above them reconstructed from plates which are fairly plentiful at the Knobs, but not observed at Whites Creek. It is of the same type as Hall's "*Cyathocrinus*" *macropleurus*,¹ which has been erroneously referred to *Vasocrinus*. It is a rare species from the Lower Burlington at Burlington, scarcely ever found except as detached plates; it also occurs at Lake Valley, New Mexico. It is hard to say how these plates can be distinguished from those of *P. crassus*, of the European Lower Carboniferous. The same type runs through the Upper Burlington—*P. doris*—into the Keokuk, where it culminates in a very large new species, which I expect shortly to describe.

2. Elongate calyx, with perfectly smooth surface, no ridges or furrows, and very thin plates; represented by the infrabasal circlet attached to proximal column joints, and a few loose basal and radial plates, all from the Knobs. Not known at Burlington, but indistinguishable in the parts preserved from specimens of *P. spissus* from Tournai, Belgium.

3. A very large, low, broadly spreading form, with stronger plates than the preceding; smooth surface, and obscure connecting ridges. RR very wide and larger than BB; facets wide and shallow, with distinct transverse ridge. IBB unknown, and characters taken from isolated basal and radial plates, found at Button-mould Knob. The general aspect is more that of *Barycrinus*; but the very distinct transverse ridge and relatively thin plates seem rather to indicate this genus. Not known at Burlington or elsewhere.

SCAPHIOCRINUS Hall.

There is a fine new species of this genus represented by several calices from Whites Creek, and a nearly complete specimen with arms from some locality in Lincoln County, Kentucky, not far from Junction City. The horizon of either might be Knobstone or Keokuk, and at neither is it positively known. There is an undescribed species somewhat similar to it in the Upper Burlington, and another in the true Keokuk at Indian Creek, Indiana.

There are also some loose smooth plates from Button-mould Knob and Stone's farm which can not be distinguished from similar plates from Tournai, Belgium.

ZEACRINUS Hall.

Z. nodosus Wachsmuth and Springer.² This singular crinoid, having the base of true *Zeacrinus* and the arms of *Scaphiocrinus*, was found by Wachsmuth at Whites Creek in a ravine washed out of

¹Journ. Bost. Soc. Nat. Hist., vol. 7, 1860, p. 295. ²Rev. Pal., vol. 3, p. 243, pl. 6, fig. 9; pl. 9, fig. 3.

clays below the level of any of the fossil-bearing beds. It has always been credited to the Keokuk, and this may be correct. It is similar to *Z. compactilis* Worthen, from Cumberland County, Kentucky, the only known specimen of which is labeled Keokuk. The form of base in these two species is unknown in the Burlington rocks.

STEMMATOCRINUS Trautschold.

S. trautscholdi Wachsmuth and Springer.¹ This remarkable species was described by us from a large series of specimens collected by Wachsmuth at Whites Creek. They were nearly all found in one locality, a plowed field in a valley filled with soil washed from the hills, some distance from the Keokuk exposures. Doctor Bassler and Mr. Braun also found several specimens, but none of them in place; all were in position where it was possible for the loose fossils to have been derived from either horizon. The genus was first observed in the Bergkalk of Moscow, Russia, whose crinoidal fauna closely parallels that of our Kaskaskia; and the only occurrence of it in this country is that of the present species, which has been supposed to be from the Keokuk. It has not been found in Barren County, or other Keokuk localities in Kentucky, or elsewhere; only at Whites Creek until now. I find loose plates of it in the débris of the Knobstone shales at Button-mould Knob, not associated with Keokuk fossils, and I think this establishes a presumption that its true horizon is Knobstone rather than Keokuk. But I state this impression subject to change upon further evidence.

BLASTOIDEA.

The genera and species of this order are usually excellent indices of stratigraphy, being restricted mostly to very definite limits. Although not abundant in these rocks, we are fortunate in finding a few which are of decisive weight.

OROPHOCCRINUS von Seebach.

This genus was short lived, and confined, so far as known, to the Kinderhook and Lower Burlington and their equivalents. In the very rich blastoid fauna of the Upper Burlington it does not occur, unless in the doubtful species, *Pentremites sirius* White, and in the Keokuk not a trace of it has ever been seen at any locality. It is therefore extremely significant that we find at Button-mould Knob the detached forked-plates of a large species of *Orophocrinus* of the same type as the well-known *O. stelliformis* of the Lower Burlington.

¹ Rev. Pal., vol. 3, p. 256.

SCHIZOBLASTUS Etheridge and Carpenter.

This genus is closely related to the one commonly known as *Granatocrinus*, a name which under the laws of priority now gives way to *Orbitremites*, from which it was separated by Etheridge and Carpenter. The two constitute essentially a Choteau-Burlington group, only one small species being from the Keokuk; two species referred to it by some authors from the St. Louis and Kaskaskia respectively probably belong elsewhere. Seven species are recognized from the Mountain Limestone of England, Ireland, and Belgium; and in this country two have been described from the Choteau, five from the Lower Burlington, six from the Upper Burlington, and one, the smallest of the genus, from the Keokuk. Besides these is the well-known and magnificent *Granatocrinus granulatus* of Roemer, by far the largest of either of these genera, which, on account of having ten spiracles instead of five, must be referred to *Schizoblastus*. Its horizon has been involved in a curious lot of guesswork. Roemer, in describing it¹, gave as its localities, on the authority of Troost and Shumard, Shelbyville, Bedford County, Tennessee, and Allen County, Kentucky; and the horizon simply as Kohlenkalk. It is referred to the St. Louis by Etheridge and Carpenter,² by S. A. Miller,³ and by Weller.⁴ Shumard in his Catalogue⁵ referred it to the Kaskaskia; while Troost, who described it in his Monograph, unpublished until lately, said it was from the Devonian.⁶ With all this lucid information in the literature to choose from, the collectors have taken another guess at it. I have specimens of this species obtained in various collections, from Bradfordsville, Sallietown, and other localities in Marion County, Kentucky, Whites Creek and Maury County, Tennessee; and they are without exception labeled Keokuk. Now it is significant that every one of these localities, as well as those given by Troost, Roemer, and Shumard, is in a region where the shales pass up from the Devonian to the Lower Carboniferous Limestone, and where the lower member of Safford's "Siliceous Group"—*i. e.*, the Knobstone—is exposed; and also that no specimen of this species has ever been reported from any typical Keokuk locality. To all this I am now able to contribute one decisive fact—namely, good specimens direct from the Knobstone shales at Stone's farm, Clark County, Indiana, in layers 40 or 50 feet above the Black Slate, and where there is no Keokuk mingled in the débris. Troost's reference to the Devonian undoubtedly meant these same shales, and the conclusion

¹ Monogr. Blastoidea, p. 43.

² Cat. Blastoidea, p. 244.

³ North Amer. Geol. and Pal., p. 250.

⁴ Bull. 153, U. S. Geol. Surv., p. 299.

⁵ Trans. St. Louis Acad. Sci. vol. 2, p. 375.

⁶ Bull. 64, U. S. Nat. Mus., p. 21.

is inevitable that at all the localities the species comes from the shales now known as Knobstone. This adds another strong confirmation to the correlation of these beds with the Lower Burlington; for the stratigraphic succession of the blastoids is quite peculiar. Certain groups of genera, to which the present one belongs, coming up from *Nucleocrinus* and *Codaster* of the Devonian, became prominent, culminated, and were practically extinguished in the Burlington. Another line, beginning with *Troosticrinus* in the Silurian, continued along moderately until the St. Louis and Kaskaskia, when it culminated in a development of the genus *Pentremites* in extraordinary profusion. In the Keokuk, between these two culminations, the blastoids were relatively rare. In the most prolific localities for crinoids, such as Crawfordsville, Indian Creek, and in Washington and Lawrence counties, Indiana, and in Barren and Metcalfe counties, Kentucky, specimens are scarcely ever found. The abundant occurrences of *Pentremites conoideus* at Spergen Hill, Indiana, and Boonville, Missouri, are from higher beds above the Keokuk—namely, the Warsaw. In the true Keokuk of the Mississippi River and Kentucky region a few straggling specimens of *Metablastus*, and the diminutive *Granatocrinus* already mentioned, are all that are ever found. It would seem, therefore, a needless stretch of the imagination to assign such a species as this to a horizon in which its group is practically extinct, instead of to one where upon every consideration of faunal succession and association it properly belongs.

S. decussatus (Shumard).¹ This species, described from Buttonmould Knob under *Pentremites*, is thought to belong to the above genus. All the specimens are imperfect, and its exact generic characters obscure, but it belongs to this group, and not to *Pentremites* as now restricted. I have some other specimens from the type locality and also from the Knobstone shales at Bradfordsville, Marion County, Kentucky. It occurs also at Fern Glen, Missouri, in shales directly underlying the typical Burlington Limestone, and is figured as a part of that fauna by Weller.²

To show the full force of the foregoing facts, I have arranged in tabular form the genera, and a few decisive species which are found at the Knob localities and Whites Creek, along with their known stratigraphical limits elsewhere.

¹ *Pentremites decussatus*, Trans. St. Louis Acad. Sci., vol. 1 p. 242.

² Bull. Geol. Soc. Amer., vol. 20, p. 288, pl. 11, figs. 28, 29.

Table of genera, and a few species occurring at the Knobstone localities and Whites Creek.

	Choteau - Kinderhook.	Lower Burlington.	Upper Burlington.	Keokuk.	Warsaw.	Mountain Limestone, Europe.	Moscow Bergk.	Knobs, Kentucky and Indiana.	Whites Creek.	
									Mixed.	Keokuk in situ.
<i>Gilbertocrinus tenuiradiatus</i>		×						×		
<i>Eretmocrinus ramulosus</i>			×	×				0	×	×
<i>Eretmocrinus prae-gravis</i>				×				0	×	×
<i>Eretmocrinus yandelli</i>			Not found elsewhere.					×	0	0
<i>Dorycrinus gouldi</i>								×	×	×
<i>Lobocrinus nashvillae</i>			×	×				0	×	×
<i>Agaricocrinus americanus</i>				×				0	×	×
<i>Agaricocrinus nodulosus</i>				×				0	×	×
<i>Alloprosallocrinus</i>				×				0	×	×
<i>Megistocrinus</i>	×	×	×			×		×		
<i>A mphocrinus</i>	×	×						×		
<i>Actinocrinus</i>			×	×		×		×		
<i>Cactocrinus</i>	×	×				×		×		
<i>Platycrinus, discoid</i>	×	×				×		×		
<i>Platycrinus, other</i>	×	×	×	×	×	×		×	×	
<i>Wachsmuthicrinus</i>	×	×						×		
<i>Mespitocrinus</i>	×	×	×			×		×		
<i>Metichthyocrinus</i>	×	×						×		
<i>Forbesiocrinus (nobilis type)</i>	×	×				×		×		
<i>Forbesiocrinus (wortheni type)</i>			×	×				0	×	
<i>Tazocrinus</i>	×	×	×	×		×		×	×	×
<i>Euryocrinus</i>						×		×	×	×
<i>Synbathocrinus</i>	×	×	×	×		×		×	×	×
<i>Halysicrinus</i>	×	×	×	×		×		×	×	×
<i>Catillocrinus</i>					St. L.			×	×	×
<i>Cyathocrinus</i>	×	×	×	×		×		×	×	×
<i>Barycrinus</i>			×	×	×			×	×	×
<i>Poteriocrinus</i>			×	×				×	×	×
<i>Scaphiocrinus</i>			×	×		×		×	×	×
<i>Stemmatocrinus</i>							×	×	×	×
<i>Orophocrinus</i>	×	×				×		×	×	×
<i>Schizoblastus</i>	×	×	×	×				×	×	×

Recapitulating these data, we have:

	Knobs.	Whites Creek.	
		Mixed.	Keokuk in situ.
Genera or particular species occurring—			
Not later than Lower Burlington.....	8	2	
Not later than Upper Burlington.....	2		
Kinderhook or Lower Burlington to Keokuk.....	10	10	
Not earlier than Upper Burlington or Keokuk.....	1	9	7
Others not definitely comparable.....	2	1	
In Mountain Limestone of Britain and Belgium.....	14	8	

These figures tell their own story better than pages of argument, which is that the main fossiliferous beds of the Knobs, and the lower limestone above the Black Slate at Whites Creek, must be placed stratigraphically as equivalent in part or closely related to the Lower Burlington. That some important Lower Burlington species are not found here, or that there may be a slight intermingling of Upper Burlington forms, does not interfere. I think there can be no doubt that the typical region of the crinoidal formation, namely,

western Illinois, eastern Iowa, and Missouri, with its long and quiet deposition of strata, was the chief habitat and center of distribution of the crinoids during that epoch; and that the occurrences in Indiana, Kentucky, and Tennessee represent migrations involving only part of the species, repeatedly interrupted and renewed, as evidenced by the frequent bands of crinoidal limestone with muddy clays and shales between. What name should be attached to these beds would probably be a matter of contention between the geologists of the different States. I am not so much concerned about that, so long as the facts are understood, and willingly leave it to those in authority to settle. But I think I may say with confidence that the name will not be Keokuk.